NETL/OPT HYDROGEN WORKSHOP
SEPTEMBER 19-20, 2000
FACILITATED BREAKOUT SESSION SUMMARIES

Summary of Utilization Group Breakout Session I

The initial discussions of the group covered the general long-term uses of hydrogen and overall drivers for interest and participation in hydrogen projects. The acknowledged long-term view was that H_2 is seen as (1) a primary transportation fuel, (2) a fuel for distributed power generation for balance, diversity, and security in distribution/supply to meet growing power needs, and (3) utilization of widely dispersed resources for power/energy needs in geographically dispersed regional energy development (such as in developing countries). The issue raised in discussion was whether the focus of project planning should be to specifically develop and demonstrate technologies needed for the long-term perceived needs, or to more practically seek opportunities for H_2 utilization in the near-term. The discussion also had issue with whether the needs should be more focused on "real" opportunities for major impact in the long term, but not yet ready for demonstration, or whether the focus should be on research improvements or limited use applications. These discussions raised the question of what the major drivers are for the use of hydrogen as a fuel form and the major drivers were concluded to be (1) carbon management, and (2) emissions reductions.

The group decided to organize the many disparate ideas that were evolving into three categories which are: (1) stationary power, (2) transportation, and (3) industrial uses. For each category, the ideas were listed and the drivers and needs were identified. These ideas, drivers, and needs were then listed in the slides used for the presentation to the workshop summary meeting and can be found in the slide package.

The discussions had three avenues of interests:

- The group believes that the major driver of concern to long-term stationary power applications including the use of hydrogen and the production facilities is carbon management. Reduction of criterion pollutants is a distant second place in driver priority in this category. However, in the transportation category, the driver priorities are reversed. A major concern in the transportation sector is the elimination or major reduction of criterion pollutants and H_2 powered vehicles (fuel cell or ICE) are perceived as a means of criterion pollutant reduction by replacement, not necessarily reducing carbon emissions. Thus, projects of interest may be more responsibly located in non-attainment areas. Conversely, the higher priority of carbon management in stationary and industrial uses seeks to attain major reductions in carbon emission, and is thus driven by carbon management. In that context, maximizing the production of H_2 and carbon sequestration have higher priorities relative to the stationary power and industrial uses than might be the case for transportation-directed projects.

- The other interesting areas of discussion as a sidelight was that a number of group members believe that the use of H_2 to enhance flame speed, combustion completion, reburning, and reduction of NO_x and PM formation could be of great interest and early-term use, but needs

some short-term research support. Improvements in this general area could impact the very large number of existing coal-based power and heat/steam facilities that represent the major resource application for the power generating sector. This could be by boiler and turbine modifications or repowering in the near-term, without the need to develop totally new technology/newly capitalized power facilities.

- The third area was that much of the efficiency improvement and effectiveness in carbon management will likely occur in integrated design. Problems and opportunities will be enhanced in the integration of processes and it is best not to look at individual process technologies alone. This would tend to mean that large, integrated projects will more likely address the opportunities better and be more successful in long-term demonstration projects, rather than attempting to demonstrate a singular technology as a component. This idea may not be completely compatible with the Vision 21 concept of modular development.

The final part of the discussion was a general time line conceptual structure for presenting the ideas. The first and earliest step would be to "find the low hanging fruit." This would be the use of H_2 in industrial or combustion uses that are almost economical now, and would likely attain enhanced performance and emissions reductions. This would be followed by fleets and then the drive to build infrastructure. The second category covers power production using H_2 with the sequestration of CO_2. This would require significant commercial incentives provided by the government to cover the extra costs and risks, and would be directed at reducing technical barriers in IGCC and fuel cells. The most practical would be repowering, or replacing of existing coal units in the power industry. The third level would be development and demonstration of H_2 infrastructure for the transportation sector. Lastly, the time line would address the full H_2 economy with a mixture of combustion and fuel cells.

Summary of Process Technology Group Breakout Session I

The group initially addressed the question: What improvements in process technology are needed to increase the likelihood of a successful commercial demonstration of hydrogen technologies? The group agreed that advances in production, storage, and conversion technologies are needed. Specific recommendations were:

- There is a need to improve separation technologies, i.e., we know how to gasify, but we need better methods of separating hydrogen from the syngas produced in the gasifier.

- There is a need for technologies that control multiple pollutants, e.g., particulates, sulfur oxides, nitrogen oxides, and HAPS. Technologies that control multiple pollutants are inherently less expensive than several technologies that each control only one pollutant.

- There is a need for improved technology to store hydrogen intended for transportation applications.

- There is a need to develop fuel cells that do not require ultra-pure fuel input.

- There is a need to reduce the capital cost of producing syngas; e.g., indirect gasification technologies should be evaluated.

- There is a need to develop technologies for producing and storing hydrogen and electricity. These technologies provide the flexibility to respond to changing market conditions, e.g., the ability to generate more electricity (and correspondingly less hydrogen) in periods of high electric demand.

- There is a need to develop the infrastructure for hydrogen storage and delivery.

- There is a need to significantly reduce the cost of carbon sequestration.

The need to reduce the cost of carbon sequestration is very important. The group agreed that the transition to a hydrogen economy would not occur unless the government mandated carbon emission reductions.

Next, the group considered the question: When are improvements in process technology likely to be ready for commercial demonstration? The group agreed that there was not enough time for improvements in process technology to have an impact on any plant that comes on line before 2005. In the midterm (2005-2010), the group felt that improvements in gasifiers, in gas separation membranes, and in the development of large-scale solid oxide fuel cells would begin to have an impact on commercial designs. In the long term (beyond 2010), the group felt that integrated gasifiers, using technology different from what is in use in commercial gasifiers today, would have a commercial impact. Some examples of different gasifier technologies under development are a gasifier being developed by ZECA (Zero Emission Coal Alliance), indirect gasification, and steam gasification.

Summary of Implementation Group Breakout Session I

The group reviewed their charge from the Agenda and identified their objectives as:

- Identify the nontechnical issues that may impact technology development and utilization of hydrogen.

- Present ideas to deal with the issues identified.

- Identify specific ways that NETL/EERE can be assisted to address their hydrogen technology development programs.

The group identified about 100 issues through a silent brainstorming session, then grouped similar items into categories which were then named. The following categories were the results of this process: (a number of specific technical issues were not included)

- Infrastructure
- Legislation/Regulation/Public Policies
- Transportation Economics (Fuel Cell)
- Production Costs (Hydrogen)
- The Consumer (Cost & Value)
- Public Perception
- Safety
- National Security
- Environmental Issues

The group concluded, following the categorization, that the key to the H_2 development puzzle was integration. The consensus was, that the following were essential:

- An Integrated Congressional Approach
- An Integrated Vision for Infrastructure
- An Integrated Sensible, Rational Policy for Energy Consistent with National and Environmental Security

To better identify ideas to deal with the issues, the group began to work through the categories listed to provide further detail. The group realized at the outset that they did not have enough information and/or time to prioritize the categories. The time allowed further breakdown as follows:

- Infrastructure

    - Tax incentives to justify the investment
    - Expand government industry partnerships
    - Expanded buy down programs
    - Consistent set of national standards (e.g., zoning)
    - Highway trust funds extended to the hydrogen infrastructure
    - Environmental fuel tax (carbon tax)

- Legislation/Regulation/Public Policy

    - Targeted R&D in common areas
    - International coordination
    - Zoning
    - Education transfer
    - Codes and standards (international)
    - Incentives/penalties

- Safety

    - Address perception and reality

        -- Education
        -- Focus groups

    - Public relations
    - Consumer advocacy organizations
    - Adequate design (zero defect)
    - Controlled (government) test program
    - Private demonstrations
    - Permanent fleet/transportation

        -- Buses, taxis, light duty

Time constraints did not permit further outline of the remaining categories.

The group took the closing minutes and identified the following practical next steps for NETL/EERE:

- Ongoing forums (communication)

    - Stakeholder feedback

- Industry strategy and needs should be communicated (stakeholders need to speak with a voice)

- NETL/EERE should promote larger budgets to address these programmatic efforts

Summary of Coal Fuel Group Breakout Session II

Recognizing the objective of this group to be focused on the identification of coal-based project ideas, the initial discussions of the group concerned the limitations and opportunities derived from this particular constraint. The group quickly reached a consensus that future hydrogen production facilities based on coal feedstocks would of necessity be relatively large central plants. The delivery, storage, handling, and preparation of coal for use in a gasification or other hydrogen production plant will be limited in the number of available sites and will need the economy of scale for project viability. Locating the project would then involve the economic trade off of coal delivery costs vs. delivery of products (H_2, electricity, and CO_2). The idea of building a small gasifier or other hydrogen producing facility co-located at a central coal-based energy facility was mentioned but not determined to be a prime concept for consideration.

Based on the group premise of a centralized coal-based production facility, the group discussions were then directed toward the kinds of projects that could be developed in the near-term that would represent a step forward in technology development, demonstration, or risk reduction. The major ideas discussed were:

- Use of existing gasifier facility as a source of a slip stream to conduct demonstration of purification/separation of H_2 and demonstration/risk reduction of providing H_2 product of a real coal-gas stream for running a vehicle fleet. Options could include local use of the H_2 product in gas turbines, SOFC, or hybrid systems.

- Development of a national test facility for development and demonstration of improved separation/purification, storage, sequestration, and coproduction technologies to accelerate commercialization of H_2 production. This was perceived to be somewhat of a Wilsonville-type of concept, only with a wholly different focus of technology and consortium of participants, with openness to new partners with technology developments.

- Development of new advanced concepts for improved H_2 production (ZECA, indirect gasification, steam gasification) and syngas separations (low temperature, cryogenics).

- Funding of CCT-like projects with the private sector building IGCC for electric power and the government providing subsidy for H_2 production aspect only.

- Variations of the coal-based premise were considered:

    - Recovery of coalbed or coal mine methane with conversion to H_2 and use of the H_2 product for mine vehicles and mining equipment (H_2 combustion or fuel cells).

    - Combined use with coal of MSW or sewage sludge in smaller scale units.

    - Pet coke gasification to H_2 on the east coast.

The discussion concluded with considerations of the most practical options to be recommended. The consensus seemed to be that the most logical option would be the use of a slipstream from an existing

facility, but that would be practically limited to Tampa, Wabash, Wilsonville, Motiva (in Delaware), or a project that might be built resulting from the current coproduction projects. These might have difficulty in gaining the participation of the current owners (particularly a commercially independent facility, such as Motiva) and also locating relative to user locations. Tennessee Eastman was later mentioned as an additional possibility. The most intriguing new idea was the coal mine methane type of project, largely because it would be a relative small facility and small investment more likely to fit a government project budget, it would have local, same site usage, and would likely involve a single major controlling participant.

Summary of Composite Fuels Group Breakout Session II

The group defined composite fuel as coal plus natural gas, sawdust, gob coal, petroleum coke, tire chips, MSW, or biomass. The composite fuel was agreed to have a nominal heat content of 10-12,000 Btu/lb.

A composite fuel demonstration project should include a gasifier using proven technology, 50 to 100 MW in size. New technology would be demonstrated on a slipstream from an existing IGCC plant. The slipstream would be used to demonstrate syngas cleanup technologies such as: hydrogen membranes, SO_2 sorbents, and H_2 purification sorbents.

The hydrogen from such a plant could be used to fire a gas turbine or fuel a power/hybrid fuel cell. In addition, the hydrogen could be used to power a fleet of buses or autos that could be covered with advertising. The advertisements would promote the demonstration project and inform the public of the benefits of converting to hydrogen fuel.

Carbon dioxide generated by a mine-mouth demonstration plant could be captured and injected into coal seams to recover methane. This methane would then be cleaned/blended to produce added fuel for the plant and simultaneously close the "green loop."

Summary of Solid Waste Group Breakout Session II

The group reviewed its assignment and defined its objectives to be:

- Determine "best fit" or ideal fit utilization driven by solid wastes
- Identify general forms of solid wastes
- Sequestration needs for system
- Power

Before trying to identify specific applications, the group identified the following resources as potential forms of solid waste fuels:

- Municipal/Industrial
- Petroleum Coke
- Mine Tailings
- Prep Plant - Coal
- Animal
- Sewage
- Biomass (wood, crops)
- Rubber Tires
- Coal

It was recognized by several in the group that it was important to start with fuels having consistent heating values. There are numerous projects, e.g., municipal solid waste (MSW) projects that have failed or had problems due to wide swings in fuel heating value.

With the various fuel sources identified, the group outlined three scenarios for utilization of waste fuel:

- Scenario I: Power

    - Potential Fuel Feedstocks

        -- Pet coke or similar wastes with coal
        -- 2500 tons/day

    - Site Selection

        -- Power station 300 MW + (2500t/d)
        -- Gasification

    - Coproduction

        -- Power, hydrogen gas turbine
        -- Other hydrogen use (end use open to economics - transportation, other)

- Sequestration (key to project)

- Eastern U.S. sites

- Scenario II: Transportation and Small On-site Cogeneration

  - Regional fleet

    -- Equipment
    -- Transportation - dual fuel

  - Federal incentive for hydrogen use

  - Potential fuel feedstocks

    -- Municipal, animal, sewage, biomass

  - Hydrogen generated at the site

  - Probably not a gasification process

    -- Biochemical approach

  - Biomass driven sequestration not an issue

- Scenario III - Industrial

  - Existing projects

    -- Delaware refinery - pet coke gasification
    -- Tampa refinery - pet coke gasification
    -- Boiler modifications (development)
    -- Add onto EECP project

  - New projects

    -- All industry

NOTE: Electronic copies (PowerPoint presentation) of the Breakout Group Summaries presented during the workshop have previously been submitted for the record.